

Intercostal Variation for Age Estimation – Are the Standards for the Right 4th Rib Applicable for Other Ribs?

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ABSTRACT

Age estimation of unknown skeletal remains is very important in forensic medicine. Morphologic methods are fast and easy to use for purpose of age determination. The sternal ends of the ribs are a reliable method of age estimation from late adolescence to old age. Iscan et al developed a phase analysis method for the right 4th rib that was sex and race specific. The purpose of this study is to determine the accuracy of the standards of age estimation from the right 4th and other rib using the phase analysis for the Turkish population. The sample consisted of right and left 3rd, 4th and 5th ribs from 34 Turkish women and 76 men. There were statistically significant variations found on the right 5th, left 3rd, 4th, and 5th ribs according to these standards in men for phases 5, 6, and 7. For women, all the right and left ribs included in this study were in concordance with right 4th rib standards in all phases.

Key words: age estimation, rib phase method, intercostal variation

Introduction

Determination of identity of individuals whether alive or dead is always required in forensic medicine¹. There are studies on age determination from the skeleton such as cranial suture closure^{2,3}, pubic symphyseal metamorphosis⁴⁻⁶, morphologic changes of the sternal end of the

rib; microscopic analysis of bone (osteon counting)⁷⁻⁹. Among these, sternal end of the rib is argued to be more reliable for age estimation from late adolescence to old age¹⁰⁻¹⁴.

Microscopic analysis requires training, equipment and time. Morphologic ex-

amination is more rapid and easier. Pubic symphysis and cranial sutures have a high degree of individual variation^{4,5}. The morphologic changes of the rib by normal aging process are sex specific^{1,9,13,14}. Iscan's rib phase method had gained widespread acceptance for both age and sex^{1,11–14}, and the need of modifications for different races has been explored^{11,14}.

The aim of this study is to search for the applicability of the standards of age estimation for the right 4th rib, for other ribs in Turkish population for right 4th.

Materials and Methods

This study includes 34 women and 76 men cases with known age, and sex, specimens were collected at the Council of Forensic Medicine of Turkey, Izmir Group Chairmanship Morgue Specialization Office between 1994 and 1996. These cases were chosen from different age groups. Sternal ends of the right 3rd, 4th, and 5th and left 3rd, 4th and 5th ribs were obtained.

The specimens were removed 5 cm from the costochondral junction. They were preserved in water for 8–64 weeks. After that the specimens were boiled for 45 minutes to remove soft tissues including costal cartilage.

This research was modeled after Iscan and associates¹. The rib samples were examined and the chronological age was estimated according to the Iscan Method that was defined for American population. The morphologic changes in the form, shape, texture and overall quality of specimens were evaluated without any knowledge about the patients. The ages were then compared with the phase assigned according to Iscan's 9 phases. These phases are defined in Table 1.

The phase mistakes were statistically compared using by Wilcoxon Rank sum test and Sign test. Weighted Kappa statistics were used to define the agreement rate among phases. Kappa values greater than 0.75 are taken to represent excellent agreement beyond chance, values between 0.40 and 0.75 are taken to repre-

TABLE 1
THE PROPERTIES OF THE RIBS ENDS ACCORDING TO DIFFERENT SEX AND AGE GROUP

Phase	Female	Male
	13 Year and below	16 Year and below
Phase 0	The articular surface is flat or billowing. The rim, regular with rounded edges. The bone is firm, solid, smooth.	The articular surface is flat or billowing. The rim, regular with rounded edges. The bones firm, solid, smooth
	14–15 Years	17–19 Years
Phase 1	The articular surface amorphous indentation beginning, ridges or billowing may still be present. The rim, regular, rounded a little waviness in some cases. The bone remains firm, solid, smooth.	The articular surface amorphous indentation beginning, ridges or billowing may still be present. The rim, regular, rounded a little waviness in some cases. The bones remain firm, solid, smooth.
	16–19 Years	20–23 Years
Phase 2	The articular surface is deeper with a V-shape, same ridges or billowing may still remain. The rim is wavy with beginning scallops at the rounded edge. The bone is firm and solid.	The articular surface is deeper with a V-shape, same ridges or billowing may still remain. The rim is wavy with beginning scallops at the rounded edge. The bone is firm and solid.

	20–24 Years	24–28 Years
Phase 3	The articular surface is deep with a V or U shape with thinner walls. The anterior and the posterior walls may start to exhibit a central, semicircular arc of bone. The bone is still firm and solid.	The articular surface is deeper with a U shape with still thick walls. The rim is more irregular but some scalloping may still be present. The bone is still firm and solid.
	24–32 Years	26–32 Years
Phase 4	An increased depth with broad V or narrow U shape occurs. The rim is irregular on a central semicircular arc with little scalloping. The bone has a little bit decrease in weight and firmness.	The depth is increasing still with U shape with thinner walls. The rim is more irregular with no scalloping. The bone has decrease in weight and firmness.
	33–46 Years	33–42 Years
Phase 5	The articular surface depth stays the same, but the walls become thinner V or U shape is wider more irregular. The rim begins to sharpen no scalloping remains. The bone is lighter in weight, density and firmness	The articular surface depth increases a little with a wider U shape with further thinning of the walls. The edges become sharp. The rim is more irregular. Scalloping pattern is completely gone. The bone is fairly good; there is evidence of porosity and loss of density.
	43–58 Years	43–55 Years
Phase 6	The pit depth at the articular surface increases, V or U shape has widened because of pronounced flaring at the end. The rim has projecting sharp points; the central arc is less obvious. The bone is fairly thin and brittle with some signs of deterioration.	The pit is noticeably deep with a wide U shape. The walls are thin with sharp edges. The rim is irregular with long bony projections, which are pronounced at the superior and inferior borders. The bone is noticeably lighter in weight, thinner and more porous.
	59–71 Years	54–64 Years
Phase 7	The pit depth shows no increase but slight decrease. Irregular bony growths are often seen extruding from the inferior of the pit. The central arc is still present with projections. The rim is irregular with sharp edges. Thin walls. The bone is very light, thin, and fragile with deterioration most noticeably inside the pit.	The pit is deep with a wide to very wide U shape. The walls are thin and fragile with sharp, irregular edges and bony projections. The bone is light in weight and brittle with significant deterioration in quality and obvious porosity.

sent fair to good agreement and values below 0.40 are taken to represent poor agreement beyond chance¹⁵.

Results

The phase distribution of 34 females and 76 males is shown on Table 2. When Wilcoxon and Sign tests statistically ana-

lyzed the phases, the morphologic changes of the all ribs of females and right 3rd, 4th ribs of males were in concordance with Iscan phase method defined for American population. However right 5th left 3rd, 4th, and 5th ribs of males have statistically significant ($p < 0.005$) difference compared by Iscan's phase method. The cases were one phase low or high. These phase mis-

TABLE 2
PHASE DISTRIBUTION OF THE CASES
ACCORDING TO RIGHT 4TH RIB

Phase	Female	Male	Total
0	4	3	7
1	3	1	4
2	4	6	10
3	4	10	14
4	8	8	16
5	2	25	27
6	7	9	16
7	1	9	10
8	1	5	6
Total	34	76	110

TABLE 3
PHASE MISTAKES IN MEN
ACCORDING TO THE RIBS*

Rib	Cases with 0 phase mistakes N (%)	Cases with (±) 1 phase mistakes N
Right 3 rd	68 (95.8%)	3
Right 5 th	64 (94.1%)	4
Left 3 rd	65 (92.8%)	5
Left 4 th	65 (91.5%)	6
Left 5 th	65 (92.8%)	5

* The Weighted Kappa values of the right 3rd, 5th and left 3rd, 4th, and 5th ribs according to the right 4th for men are 0.97, 0.97, 0.95, 0.95 and 0.95 (excellent agreement)

takes (in concordance) are summarized at table 3. We were unable to examine 17 ribs in 7 cases because of problems such as the soft tissues not separating after multiple boiling, or the sternal rib end had been damaged. Weighted kappa values of the right 3rd, 5th and left 3rd, 4th, 5th ribs according to the right 4th rib phase distribution for women were 1.00 showing an excellent agreement. The Weighted Kappa values of the right 3rd, 5th and left 3rd, 4th and 5th ribs according to the right

4th for men are 0.97, 0.97, 0.95, 0.95, and 0.95 respectively.

Discussion

The sternal extremity of the rib undergoes continuous metamorphosis as a normal part of the aging process. The rates of these changes are paralleled to age and these changes are also different in females and males requiring the development of different standards. Female ribs begin to show changes earlier than males¹⁰.

Several factors affect the use of a method of age estimation from the skeleton. These factors include inter-observer error, human variability, occupation, general health and the effects of disease⁹. The main health problems that affect bone remodeling are endocrine disorders, chronic lung disease or medication. Intercostal variations, degree of physical activity, diet and racial differences may be some other affecting factors^{11,14}. Racial differences are a product of both genetics and environment. It is reported to be relatively low in age determination from the adult skeleton. Iscan et al found differences in the ribs both in rate and morphological pattern of aging between whites and blacks¹³.

In this study, we examined intercostal variations. We first determined the usability of Iscan's phase method for Turkish people and this study was performed to determine the applicability of the standards of age estimation from the right 4th rib by phase analysis for Turkish population on the other ribs. The statistical analysis did not show difference between the phases of American and Turkish people at the right 4th rib. Thus, the phase method of age determination is safely used in this study.

There are some -1 or +1 phase variations at each rib whether left or right in men. However the number of cases with

phase mistakes is the lowest at right 4th rib. There was a statistically significant difference for the changes of the right 5th, left 3rd, 4th, and 5th ribs according to these standards in men for phases 5, 6, and 7. For women, all the right and left ribs included in this study were in concordance with right 4th rib standards in all phases. Weighted Kappa values of the right 3rd, 5th and left 3rd, 4th, 5th ribs according to the right 4th rib phase distribution for women were 1.00 showing an exact agreement. The weighted kappa values of the right 3rd, 5th and left 3rd, 4th, 5th ribs according to the right 4th for men are in excellent agreement values beyond chance.

Intercostal variation is not observed in the early phases in men and in any phase in women in this Turkish population series. The statistically significant variation among ribs in men, not in women, might be explained by a few hypoth-

eses. Individual differences in the rate of growth and remodeling among ribs in the late phases might mainly be affected by phenotypic factors. In Turkey the male population has more differences in life standards than women, such as nutrition, disease, sport activities, type of work. This variation may be accepted minimum because kappa statistic defines agreement with the 4th rib. This minimum variation rate must not cause a disadvantage to be able to use different ribs, and right or left ribs in age estimation. This hypothesis was strongly supported by weighted kappa statistics that showed excellent agreement rate.

We conclude that Iscan's rib phase analysis method is applicable for using in age estimation for Turkish population. This method may be used in all right and left 3rd, 4th, 5th ribs with little variations in men defined for each rib.

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VARIJACIJE MEĐU REBRIMA U ODREĐIVANJU DOBI – JESU LI STANDARDI ZA 4. DESNO REBRO PRIMJENJIVI I ZA DRUGA REBRA?

S A Ž E T A K

Određivanje dobi nepoznatih skeletnih ostataka vrlo je važno u sudskoj medicini. Morfološke metode su brze i jednostavne za upotrebu u cilju određivanja dobi. Određivanje dobi na osnovi sternalnih krajeva rebara pouzdana je metoda kod starijih adolescenata pa sve do starosti. Iscan i suradnici razvili su metodu fazne analize za desno 4. rebro koje je spolno i rasno specifično. Cilj ove studije bio je odrediti preciznost standarda procjene dobi na osnovi desnog 4. rebra te drugih rebara u populaciji Turske korištenjem fazne analize. Uzorak su sačinjavala desna i lijeva 3. 4. i 5. rebra 34 žena i 76 muškaraca i Turske. Pronađena je statistički značajna varijacija kod desnog 5., lijevog 3, 4, i 5. rebra u odnosu na standard za muškarce za 5, 6 i 7 fazu. Kod žena, sva desna i lijeva rebra uključena u ovo istraživanje bila su u skladu sa standardima za 4. rebro u svim fazama.